TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE
IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XXI. No. 11. NOVEMBER, 1944. PRICE 6d.

CONTENTS.

	PAGE
The Nutrition Society	201
Unusual Correlation between Insect Damage and Crop Harvested	202
The Contributions made by Sugar-Cane Roots to Soil Organic Matter	203
Rooting Cuttings of Coffea Arabica ...	209
The Determination of Polarisation % Cane for the Purpose of Field Allocations of Sugar or as a Basis of Cane Payment	211
Miscellaneous Notes	213
An Improved Water Lift...	214
Stubble-Mulching and Subsurface Tillage ...	215
Chemical Notes	216

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 0365

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and Subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, Grand Buildings, Trafalgar Square, London, W.C. 2, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

THE NUTRITION SOCIETY

During 1941 and 1942 action was taken by research workers in Great Britain to form a society which would bring together those concerned with nutrition in the agricultural, medical and domestic sciences and in the food industry. This new society has just published the first issue of its journal, the Proceedings of the Nutrition Society.*

The meetings of the Society are more in the nature of symposia than the usual scientific meeting where individuals present reports on their own current research. At each meeting some portion of the field of nutrition is selected for examination and the discussions are led by specialists in the appropriate subjects. In addition, one meeting is integrated with another so that the problems of nutrition are examined in a logical and orderly manner. The Society publishes both the original communication and an abstract of the subsequent discussion.

Because of transportation difficulties during wartime the Society has two sections, the English and the Scottish, which hold independent meetings. The principal officers of the Society are Sir John Boyd Orr (Chairman), Dr. J. Hammond (Vice-Chairman), Mr. A. L. Bacharach (Treasurer) and Dr. L. J. Harris (Secretary).

The first Scientific Meeting of the Scottish Section of the Society was held to examine the latest standard of human dietary requirements. This new standard, the Recommended Daily Allowances for Specific Nutrients, was presented by the Committee on Food and Nutrition of the United States National Research Council in 1941. It represents a series of modifications of the earlier standards of the British Medical Association (1933), of Stiebeling (1933) and of the League of Nations (1936) in view of more recent laboratory and clinical research. The adequacy of the recommended allowances for the different nutrients were discussed by Cuthbertson (calories, protein and fat), Duckworth (calcium and iron) and Ungley (vitamins A, B1, C, D, riboflavin and nicotinic acid).

At the second Scottish meeting the translation of human requirements into terms of foodstuffs was considered. Leitch presented data shewing what changes in food supplies were necessary to

**Proceedings of the Nutrition Society*, Vol. 1, Nos. 1 and 2, W. Heffer & Sons Ltd., Cambridge, England. Price per Volume: 25s. net. Price per number; 15s. net.

raise the British diet from its pre-war level of inadequacy (for certain economic groups) to levels of adequacy as defined by different standards. The extent to which British agriculture can cover the increased requirements was examined by different speakers. Lovern shewed that, for the fishing industry, only the herring catch is capable of significant expansion and that, in this case, improved methods of refrigeration and cold storage are essential for future development. Wannop examined the effect on crop policy and drew attention to the need for a greater home production of protein for livestock feeding.

The potential contribution of milk, meat and eggs was discussed by Wright. This speaker examined the increased requirements for animal products in terms of the capacity of the British livestock industry to produce them, drawing attention to the balance and interdependence between different classes of livestock and the division of feeding stuffs between these classes. Emphasis was placed on the effect of attempts to be made to raise the nutritional level of tropical peoples on the supply of oilseed residues as protein concentrates. Wright shewed that about 55 per cent. of Britain's oilseed products came from India and Africa and suggested that the needs of tropical peoples would be better served if the oil alone were exported to Britain for margarine manufacture and the seed residues were retained for use as feedingstuffs for tropical dairy cattle. This view fits in well with Wannop's suggestion of a greater domestic production of protein in the form of pasture grass, a procedure well within the capacity of British agriculture.

The first meeting of the English Section considered methods of evaluating the nutritional status of man and animals. Harris described clinical methods of detecting partial vitamin deficiencies and Platt spoke of assessing the state of nutrition in Oriental and African peoples. Crowther, Green and Hammond dealt with various aspects of energy, protein, mineral and vitamin requirements and deficiencies in farm stock in different parts of the world.

The second English meeting discussed food production and distribution in relation to nutritional needs. Orr opened the discussion with an examination of the agricultural implication of a food policy based on nutritional needs and drew attention to the importance of growing more foods which can be consumed directly by man. The need of international co-operation to see that easily transported foodstuffs were produced in those areas capable of producing them most efficiently was emphasised. In describing the relation between animals and man on the one hand and food and feedingstuff supplies on the other, Wright shewed how this was a complementary relation in peace time. With the outbreak of war the relation became, to some extent, competitive. Thus the inclusion of increased amounts of bran in Britain's natural flour served to reduce by the same amount the total quantity of milling by-products available for stock feeding. Halnan compared the efficiencies with which different classes of livestock converted the protein and energy of feeding stuffs, in forms largely inedible by man, into animal products suitable for human consumption and indicated that the dairy cow was the most efficient converter. The problems of planning for agricultural production were examined by Russell who considered that the main difficulty facing post war increases in domestic production was financial rather than technical. He felt that the best type of arrangement was one whereby farmers, represented by their Unions, negotiated with a Purchasing Board, set up by the Government, to arrange a series of contracts for stipulated quantities of food stuffs at prices fair to consumers, farmers and farm workers.

Problems of collective feeding in wartime were discussed at the third English meeting. The Minister of Food, Lord Woolton, opened the meeting with some references to the function of the Ministry of Food in collective feeding. At that time, 1942, there were 1400 state-operated British Restaurants and 7500 industrial canteens. Various speakers dealt with the provision of meals in factories, schools and the armed forces attention being given to the effect of large scale preparation on the nutritive value of foods and to the exploiting of the opportunities of educating the public to discriminate in the choice and preparation of different foods.

During the first six months of its existence the Nutrition Society has covered a large field. It is gratifying to note that wherever the need of improving the British diet was discussed, attention was directed to the need for integrating the methods with those of other countries and, particularly, to preventing an improvement being attained at the expense of tropical peoples. The references to the necessity of considering not only domestic agriculture but also the production problems in other countries and trade relations and commitments indicate a breadth of vision which the uninitiated do not always expect to find in scientists.

J.D.

UNUSUAL CORRELATION BETWEEN INSECT DAMAGE AND CROP HARVESTED.

At the Tea Research Institute, Ceylon, an experiment is described by which an attempt was made to determine the effect of manurial treatments on the damage caused by the shot-hole borer of tea (*xyleborus fornicatus* subsp. *fornicator*). Increases in yields of the plots were accompanied by increases in the damage caused by the beetles as measured by the number of broken branches—an unusual correlation between pest damage and harvest ($r = +0.9267$). The experiment failed to indicate clearly the cause of increased damage following manuring, but possibly it results from an increase in the number of galleries formed ($r = +0.6547$). (Author's summary.)—(*Horticultural Abstracts*, XIV, No. 2, 1944).

THE CONTRIBUTIONS MADE BY SUGAR-CANE ROOTS TO SOIL ORGANIC MATTER

(With particular reference to Trinidad and Barbados)

BY

F. HARDY

(*Imperial College of Tropical Agriculture*)

(I) Introduction

The death and decay of the roots of the sugar-cane distributed in the upper layers of the soil are believed by some authorities to contribute materially to the maintenance of the supply of organic matter and thus to constitute an important factor in the productivity of sugar-cane lands. Quantitative data pertaining to this question are widely scattered in the literature and published results are usually expressed as weight of roots per stool, no mention being made of the number of stools per acre, so that it is not possible accurately to derive the magnitude of the organic matter contribution reckoned as percentage of soil or as pounds per acre of land. Certain exceptions may be noted, for example, the data presented by Atherton Lee concerning sugar-cane root distribution in the soils of Hawaii (1). These include weights of cane roots, sifted with a 1/4 inch sieve out of the excavated soil surrounding individual stools of different cane varieties, expressed as grams, for each of three, four or five successive 8-inch layers. From the combined results, the conclusion is drawn that, on the irrigated plantations of Hawaii, the amount of dry organic matter returned as dead roots per acre by each crop of sugar-cane ranges from 18 to 37 hundredweights (cwt.). More than 58 per cent. of the roots occur in the top 8-inch layer and about 85 per cent. are in the top 24-inch layer. In some cases, over 70 per cent. of the roots occur in the top 8-inch layer. Hence, the contributions made per acre of land by the roots to the organic matter content of the top 8-inch layer lies between 10 and 24 cwt., or, taking the weight per acre-8 inches of soil as 2.7 million pounds, 0.04 to 0.10 per cent. of the weight of soil.

This result is relatively insignificant, and it would be interesting to know if it is substantiated by data obtained in sugar-growing countries other than Hawaii. Without attempting an exhaustive survey of results published in the voluminous literature on the sugar-cane which doubtless would yield much information of value, it is desired here to present comparative data for certain soils in Trinidad and Barbados that have come to the writer's notice in recent years.

(II) Data from Trinidad

During 1928-1931, the writer undertook an investigation by the soil-core method of the distribution of sugar-cane roots in different soil-types occurring in Trinidad. The results were ultimately published in condensed form in an article that appeared in this Journal (2). From the actual weights of roots sifted out through a 1 mm. sieve with the aid of running water, the following table has been constructed (Table I). The figures are average weights in grams of oven-dried roots per soil-core having dimensions 3 inches diameter and 6 inches long (volume, 695 cc.). Each figure is a mean of values obtained for three cores along a line drawn parallel to a drain from a stool to a point midway to the next stool, repeated for five typical stools, thus involving 15 cores in all. In some cases, the whole trial was replicated three or four times. Each figure thus represents the mean quantity of dry root matter distributed in the soil around the stool, but it does not include roots occurring immediately below the base of the stool and must therefore be regarded as a low estimate of total root matter. Each 6-inch layer was sampled separately so as to explore the soil both vertically down to the 36-inch depth and laterally for a radial distance of about 20 inches, which is about half of the distance between stools, canes being planted 3 feet apart in Trinidad.

Discussion of root weight data (Table I)

(i) Greatest root weight is produced by clay soils as compared with sands. The black clay soil derived from marl produces least root weight, possibly because its open granular structure causes it to behave as a coarse sand.

(ii) Most roots (about 40 per cent.) occur in the top 6-inch layer in each case and about 60 per cent. in the top foot; about 85 per cent. occur in the top 2 feet of soil.

(iii) Roots of ratoons are more plentiful in the top 6-inch layer than roots of plant-canes.

(iv) Roots of the thin-stemmed Uba variety are concentrated more in the top 6-inch layer than roots of varieties of "noble" canes in corresponding stages of growth.

Conversion of data to weight per cent. of soil

To convert values for weights of dry root matter contained in a single core to weight per cent. of soil, the amount of dry soil contained in a typical core for each of the kinds of soil sampled must first be known; *i.e.*, the apparent specific gravity of the soil is needed. This information was not obtained at the time of root sampling but recent investigations into the porosity of sugar-cane soils in Trinidad furnish the required additional facts. These are set out in Table II.

Table I

Average Weights of Cane-Roots Matter per Soil-Core for Chief Soil-Types of Trinidad

(Volume of core, 696 cc.)

Field	Variety	Stage	Age (mths)	Total No. of cores averaged	Thickness of layer (inches) 0-6	6-12	12-18	18-24	24-30	30-36
(A) CLAY SOILS										
(a) Grey-fawn Clay					(Weights in grams)					
(I) *Waterloo Estates*										
(1) "Bad" plot ...	B 6308	3rd rats.	6½	60	1.74	1.24	0.73	0.38	—	—
(II) *Caroni Estates*										
(2) "Bad" Plot ...	BH 10/12	Plants	10	15	0.92	0.49	0.20	0.21	0.15	0.17
		Means			1.33	0.86	0.46	0.29	0.15	0.17
					Total roots, 3.26 g.					
(b) Red Clay										
(III) *Ste. Madeleine Estates*					(Weights in grams)					
(3) "Bad" Plot ...	BH 10/12	1st rats.	12	15	1.82	1.02	0.72	0.47	0.59	0.39
(4) C.H. 5	Uba	Plants	16	15	2.27	1.78	0.89	0.52	0.48	0.35
(5) Cor. 19	Uba	1st rats.	10½	15	1.87	1.58	0.92	0.52	0.49	0.35
(6) CH 107	Uba	Old rats	9	15	4.11	1.11	0.62	0.52	0.48	0.41
		Means			2.52	1.37	0.79	0.51	0.51	0.37
					Total roots, 6.07 g.					
(c) Black Marly-Clay										
(7) P.M. 50	B.H 10/12	Plants	14	15	1.29	0.78	0.76	0.45	0.39	0.36
(8) "Good" Plot ...	BH 10/12	1st rats.	12	15	0.97	0.68	0.35	0.28	0.29	0.23
		Means			1.13	0.73	0.55	0.36	0.34	0.29
					Total roots, 3.40 g.					
(B) SANDY SOILS										
(I) *Waterloo Estates*					(Weights in grams)					
(9) Camd. 13 ...	B 6308	3rd rats.	6½	45	1.60	0.91	0.50	0.40	—	—
(10) Exch. 7 ...	BH 10/12	Plants	6	15	1.31	1.03	0.76	0.62	—	—
(11) Exch. 8 ...	BH 10/12	1st rats.	8	15	1.75	0.85	0.61	0.36	—	—
(12) Exch. 2 ...	BH 10/12	2nd rats.	6	15	1.56	0.70	0.41	0.36	—	—
(13) Union 25 ...	Uba	Plants	12	15	0.91	1.31	0.48	0.09	—	—
(14) Exch. 24 ...	Uba	2nd rats.	9	15	(2.82)	0.81	0.42	0.30	—	—
(II) *Caroni Estates*										
(15) "Good" Plot ...	BH 10/12	Plants	10	15	0.78	0.48	0.32	0.23	0.33	0.24
(III) *I.C.T.A.*										
(16) Field K ...	BH 10/12	Plants	10	15	1.23	1.18	0.85	0.72	0.26	0.25
		Means			1.31	0.91	0.54	0.38	0.30	0.25
					Total roots, 3.69 g.					

Table II

Apparent Specific Gravity of Plot Soils

(Thickness of layer in inches)

Soil	Apparent Specific Gravity						Weight of dry soil in a single core (g.)					
	0-6	6-12	12-18	18-24	24-30	30-36	0-6	6-12	12-18	18-24	24-30	30-36
(A) CLAY SOILS												
(*a*) GREY-FAWN CLAY												
Waterloo "Bad" Plot ...	1.30	1.33	1.29	1.31	1.30	1.30	904	927	897	910	915	915
Caroni "Bad" Plot ...	1.28	1.39	1.46	1.42	1.40	1.40	890	966	1015	987	990	990
(*b*) RED CLAY												
Ste. Madeleine "Bad" Plot	1.02	1.02	1.04	1.02	1.05	1.05	709	709	723	709	710	710
(*c*) BLACK MARLY-CLAY												
Ste. Madeleine "Good" Plot	1.10	1.12	1.17	1.16	1.20	1.20	765	778	813	806	810	810
(B) SANDY SOILS												
Caroni "Good" Plot ...	1.40	1.46	1.49	1.47	1.50	1.50	973	1015	1036	1022	1030	1030

NOTE.—The plots are contrasted ½-acre areas established in connection with ecological studies. The terms "good" and "bad" are merely relative; they refer to yielding capacity.

Applying these values for weight of dry soil comprising a core of volume 695 cc. to the corresponding data for root matter contents, the results set out in Table III emerge.

Table III

Percentage Cane-Root Matter in Plot Soils

Soil	Percentage of root matter at different depths (inches)					
	0-6	6-12	12-18	18-24	24-30	30-36
(A) CLAY SOILS						
(*a*) GREY-FAWN CLAY						
Waterloo "Bad" Plot ...	0.192	0.134	0.081	0.042	—	—
Caroni "Bad" Plot	0.102	0.051	0.019	0.021	0.015	0.017
(*b*) RED CLAY						
Ste. Madeleine "Bad" Plot ...	0.256	0.144	0.099	0.066	0.083	0.055
(*c*) BLACK MARLY-CLAY						
Ste. Madeleine "Good" Plot ...	0.127	0.087	0.043	0.035	0.036	0.028
(B) SANDY SOILS						
Caroni "Good" Plot ...	0.080	0.047	0.031	0.022	0.032	0.023

Assuming similar specific gravities for the main soil-types which the plot soils closely resemble, the following generalised results are obtained for Trinidad (Tables IV, V).

Table IV

Percentage Cane-Root Matter in Chief Soil-Types of Trinidad

	Percentage of root matter at different depths (inches.)					
	0-6	6-12	12-18	18-24	24-30	30-36
Clay Soils						
Grey-fawn clay...	0.148	0.092	0.049	0.031	0.015	0.017
Red clay	0.355	0.193	0.108	0.072	0.072	0.052
Black marly-clay	0.149	0.092	0.068	0.045	0.042	0.036
Sandy Soils	0.134	0.089	0.052	0.037	0.029	0.024

Table V

Mean Percentage Cane Root Matter for Increasing Depths of Soil

Depth of layer (inches)	Clays			Sands
	Grey-fawn	Red	Black	
0-6 ...	0.148	0.355	0.149	0.134
0-12 ...	0.120	0.274	0.120	0.111
0-18 ...	0.096	0.219	0.104	0.092
0-24 ...	0.080	0.182	0.089	0.076
0-30 ...	0.067	0.160	0.080	0.068
0-36 ...	0.059	0.142	0.073	0.061

Discussion of percentage data (Tables III, IV, V)

The mean magnitude of the organic matter contribution to the surface 6-inch layer by cane-roots in Trinidad is thus probably about 0.15 per cent. for the majority of soils, though apparently considerably larger (more than twice) for the red clay of the Ste. Madeleine estates. Vertical distribution is regularly proportionate for each kind of soil. In terms of organic matter per acre 6-inches (or 2 million pounds weight of soil), this mean magnitude is equal to 3,000 lb. or 27 cwt. per acre, which is somewhat higher than Atherton Lee's figure for Hawaiian soils already quoted, namely, 10 to 24 cwt. per acre 8-inches, mean 17 cwt. It should be noted, however, that Hawaiian soils have a much more open granular structure than the Trinidad clay soils so that they behave more like sands in which root ramification and branching are not so prolific as they are in clays.

Note.—The Ste. Madeleine red clay soil is not a "lateritic" type like the Hawaiian red soil. It is derived from grey kaolinic siltstone which weathers red and not from igneous and volcanic rocks as are the friable red soils of Hawaii.

(III) Data from Barbados

During 1933-1934, G. C. Stevenson and A. E. S. McIntosh carried out an investigation by the soil-core method of sugar-cane root distribution in black clay soil characteristic of the lower coralline lands of Barbados. Their results were published in detail in a bulletin issued by the British West Indies Central Sugar-Cane Breeding Station (3). The method devised for root sampling thoroughly explored an area about 5 square yards in extent, subtended by three cane-stools, within which 19 cores were procured by means of a turf cutter. From the actual recorded weights of roots that were sifted out through a 2 mm. sieve with the aid of running water, the following table has been constructed (Table VI). The figures are weights in grams of air-dried roots per soil-core having dimensions 6 inches diameter by 6 inches long (volume, 2783 cc.). The roots collected at the fourth examination when the plants were 15½ months old alone are considered, since these gave maximum values for root matter. The weights of absorbing and non-absorbing roots, given separately in the original bulletin, are combined in Table VI herewith. Each 6-inch layer down to 18 inches was sampled separately. It was not feasible to sample deeper, since rubbly coral rock occurred at depths greater than about 24 inches.

Table VI

Average Weights of Cane-root Matter per Soil Core Barbados Black Clay Soil

(Volume of core, 2783 cc.)

Variety	Total No. of cores averaged	Thickness of layer (inches)			Total weight
		0-6 ins.	6-12 ins.	12-18 ins.	
B.H 10/12	19	2.85	0.67	0.38	3.90
Ba 11569 ...	19	0.57	0.35	0.44	1.36
B 726 ...	19	2.78	1.49	1.12	5.39
POJ 2878...	19	1.51	1.30	0.71	3.52
Co 281 ...	19	1.95	1.63	1.41	4.99
Means		1.93	1.09	0.81	
		3.83 g.			

Discussion of root weight data (Table VI)

(i) Greatest root weight was produced by B. 726 variety and least by Ba. 11569.

(ii) Most roots (50 per cent.) occurred on the average in the top 6-inch layer.

(iii) The depth distribution of roots was very variable, certain varieties showing better root penetration than others.

(iv) Root concentration in the top 6-inch layer was greatest for BH 10/12 (73 per cent.) and next greatest for B. 726 (52 per cent.) ; it was least for Co 281 (39 per cent.).

The varieties thus show considerable individuality in their root growth.

Conversion of data to weight per cent. of soil

To convert each value for weight of dry root matter contained in a core of volume 2783 cc. to weight per cent. of soil, the amount of dry soil comprising a single core must be known. This was not stated by the investigators but, assuming the Barbados black clay soil resembles the Ste. Madeleine black marly-clay soil in Trinidad (which it appears or does closely on account of its similar origin and pedological relationships), then the values for apparent specific gravity, given for that soil in Table II may be applied also to the Barbados soil. The results obtained are set out in Tables VII and VIII.

Table VII

Percentage of Cane-Root Matter in Barbados Black Clay Soil

(Plant canes)

Variety (Plant canes)	Percentage of root matter at different depths.		
	0-6 ins.	6-12 ins.	12-18 ins.
BH 10/12 ...	0.093	0.021	0.011
Ba 11569 ...	0.019	0.011	0.014
B 726 ...	0.091	0.048	0.035
POJ 2878 ...	0.049	0.042	0.021
Co 281 ...	0.064	0.052	0.043
Means ...	0.063	0.035	0.025
For comparison : Ste. Madeleine black marly-clay.			
BH 10/12 (Plants)	0.169	0.100	0.093

Discussion of percentage data (Tables VII, VIII)

The mean amount of organic matter contributed to the surface 6-inch layer by cane roots in the Barbados experiment is about 0.063 per cent. and that by roots of plant-canes of the BH 10/12 variety, 0.093 per cent. This latter quantity is only a little more than half that for the same variety and stage of growth in similar soil in Trinidad. Moreover, the distribution of cane roots is apparently deeper in the Trinidad black marly-clay soil (Table VIII). These differences may be attributed chiefly to the fact that, in the Barbados experiment, each unit area sampled was subtended only by a single row of three cane stools instead of by two rows, blank sites on one side being deliberately left unplanted. Thus the concentration of cane-roots within each unit volume of soil was approximately only a half of what it would normally have been had no gaps been left in the planting. When due allowance is made for this irregularity, then the similarity between root matter contents of the black clay soil of Barbados and the black marly-clay soil of the Ste. Madeleine estates of Trinidad becomes apparent.

(IV) Conclusions : Cane-Root Organic Matter

The Barbados data on the whole substantiate the Trinidad data and support the conclusion that cane-roots left in the soil when the crop is reaped in these two countries may contribute the following average amounts of organic matter to the top 6-inch layer of the soil, namely :— 0.15 per cent. for grey-fawn clays, 0.36 per cent. for red clays, 0.13 per cent. for black clays and 0.13 per cent. for sands.

These values when converted to hundredweights per acre top 6-inches of soil, assuming that this weighs 2 million pounds, are approximately 27, 64, 23 and 23 cwt. respectively ; mean 35 cwt. per acre 6-inches.

(V) Comparison with Cane-Trash

Compared with cane-trash, root residues would appear to provide a somewhat inadequate source of soil organic matter for, assuming that one-half

Table VIII

Mean Percentage Cane-Root Matter for Increasing Depths of Barbados Black Clay Soil

(Plant canes)

Depth of layer (inches)	BH 10/12 (A)	Ba 11569	B726	POJ2878	Co281	Means	Ste. Madeleine Black Marly Clay for comparison (BH 10/12 ; Plant canes, (B)	Percentage (A)	Percentage (B)
0- 6	0.093	0.019	0.091	0.049	0.064	0.063	0.169	48*	40
0-12	0.057	0.015	0.070	0.046	0.058	0.049	0.134	30	31
0-18	0.042	0.105	0.058	0.037	0.053	0.041	0.121	22	29

of the mature cane-plant consists of leaves and tops, then a 40-ton crop of cane stalks would be accompanied by 20 tons of leafy material* left on each acre of land. Assuming that this material on the average contains 50 per cent. of organic matter, then the amount of dry trash which it would yield is 10 tons or 200 cwt. per acre which is about 6 times the weight of root residues which the crop would leave in the top 6-inches of soil.

Comparison of root-residues with cane-trash as humus-formers

Neither root residues nor trash have much value as soil improvers until they are completely converted into colloidal humus. The process of humification is controlled mainly by soil micro-organisms and the product, humus, consists largely of the dead proteinous remains of these agents. During humification, a loss of carbon occurs through oxidation and an accumulation of nitrogen proceeds until the carbon-nitrogen ratio is reduced to about 10 and the carbon content of the product is about 56 per cent. of its weight.

Root residues differ in chemical composition from trash, being more ligneous and more nitrogenous. According to data in the literature and actual analyses performed in the Chemistry Department of the College, root residues contain about 1.6 per cent. of total nitrogen with carbon-nitrogen ratio about 27, while cane-trash contains about 0.6 per cent. of nitrogen with carbon-nitrogen ratio 64. Thus, whereas 1.6 parts of nitrogen are associated with every 100 parts of root material, this amount of nitrogen is associated with only 28.6 parts of soil humus. Similarly, whereas 0.6 parts of nitrogen are associated with every 100 parts of cane-trash, this amount of nitrogen is associated with only 10.7 parts of humus. Thus 35 cwt. of root residues (the mean amount found to be left in one acre 6-inches of soil by an average cane-crop) would produce 10 cwt. of humus in the soil, and 200 cwt. of cane-trash (the amount returned to the soil per acre by an average crop) would produce 21½ cwt. of soil humus, which is more than twice as much.

Reckoned in terms of percentage contributions to the surface 6-inches of soil weighing about 2 million pounds, these values become 0.056 per cent. and 0.120 per cent., representing the amount of humus increment† that might be expected from root residues and trash respectively for each crop of sugar-cane reaped. How long the humic products may take to decay further, yielding up some of their store of nitrogen to succeeding cane-crops, cannot be conjectured, since the process is controlled by a great many variable factors. It is evident, however, that more benefit may be expected from residues of the leafy parts of the cane-plant than from the roots and for this reason cane-trash should be rigorously conserved under all circumstances.

Importance of the natural organic profile

The advantage of returning vegetable residues to the soil surface instead of burying them have been repeatedly stressed in recent years by agricultural writers; presumably the arguments apply also to cane-trash left to rot on the land as compared either with cane-trash buried in the soil or with root residues already incorporated therein.

Evidence has recently been obtained in Mauritius by means of field experiments continued over four successive years that burying cane-trash with or without artificial manures gives no significantly higher yields than merely heaping the trash on the surface (**4**). Regarding the effects of root residues, it has also been demonstrated in Mauritius by field observations and pot experiments that cane-root residues may actually exert toxic effects during their decay in the soil. It was shown that the "growth of one variety was not only decreased by roots of another variety but also by its own roots" (**5**).

One of the main advantages of applying cane-trash continuously or periodically to the land is that it gradually produces a characteristic stable porous structure in the upper part of the soil profile, as well as a conspicuous superficial crumb layer, particularly suited to the acceptance of rain water which is able freely to infiltrate into it. Both air and water may simultaneously occur within such highly porous humic soil, and danger of water-logging and of loss of rich surface soil by sheet erosion are prevented. Furthermore, a trash cover reduces water-loss by evaporation and also protects the structured soil from compaction by beating rain. The formation and maintenance of a normal organic profile by the slow downward penetration of the products of the natural decomposition of vegetable residues added to the surface of a soil are thus to be encouraged, since the resulting structure is eminently suited to the proper development of plant root systems.

(IV) Summary

(1) Evidence is adduced from actual weights of root residues contained in soil-cores procured during root distribution investigations in Trinidad (by the writer) and in Barbados (by Stevenson and McIntosh) to show that the contribution which these residues make to the supply of soil organic matter is unsuspectedly small, being of the order of 35 cwt. per acre 6-inches of soil, or 0.20 per cent. of soil weight.

* Consisting partly of dry trash, senescent freshly stripped leaves and fresh green leaves and tops.

† Taking the organic humic matter content of the top 6-inch layer of sugar-cane soils in Trinidad and Barbados as about 4 to 3 per cent. for black clays and 3 to 2 per cent. for other types, then these contributions will range between 2.8 and 1.4 per cent. for root humus and between 7.0 and 3.5 per cent. for trash humus, on the original humic content of the soil.

(2) Variations in the magnitude of the contribution are noted, according to type of soil, variety of cane and stage of growth.

(3) By contrast, cane-trash contributes considerably greater quantities of organic matter of the order of 200 cwt. per acre, or 1.14 per cent. on soil weight.

(4) In each case humification within or on the soil reduces the contribution to 10 cwt. for root residues and 21½ cwt. for cane-trash per acre of canes as rough estimates, cane-trash thus contributing more than twice as much humus to the soil as cane root residues.

(5) When incorporated into the surface 6-inch layer, these quantities are equal to about 0.056 and 0.120 per cent. of the weight of the soil.

(6) The advantages of adding cane-trash to the soil as contrasted with burying it below the surface are emphasised, and the possible toxic effects accompanying the decay of root-residues in the soil are indicated.

(V) References

(1) The Distribution of the Roots of Sugar-Cane in the Soil in the Hawaiian Islands. H. Atherton Lee, *Plant Physiology*, I, 1926, pp. 363-378.

(2) Root Distribution of Sugar-Cane in Different Soils in Trinidad. F. Hardy, *Tropical Agriculture*, X, 1933, pp. 165-172.

(3) Investigations into the Root Development of the Sugar Cane in Barbados. (1) Root Development in Several Varieties under one Environment. G. C. Stevenson and A. E. S. McIntosh, *Bul. No.* 5, Feb. 1935, *B.W.I.C.S.*; *C.B.S.*, pp. 1-44 and figs. i-xxi.

(4) Experiments on the Disposal of Trash. H. Evans, *Annual Reports, Sugar Research Station*, Mauritius, 9th to 12th, for years 1938 to 1941 inclusive.

(5) Toxicity of Sugar-Cane Roots. H. Evans, *ibid.* 7th Report for 1936, pp. 38-39.

ROOTING CUTTINGS OF COFFEA ARABICA

A Cost Analysis

BY

S. M. GILBERT,

(*Chief Scientific Officer, Coffee Research and Experimental Station, Lyamungu, Moshi, Tanganyika Territory*)

This article has followed the form of one on cacao (1) written by Cheesman and Spencer and published in 1940. In adopting this form the object has been to render easy a comparison between the two crops. The comparison reflects the advantage of cheaper labour in East Africa.

The work of rooting cuttings of *Coffea arabica* has proceeded without serious interruption, on a fairly large scale, from 1939 to date. It continues with slight handicaps due to war conditions; such as shortage of glass and inability to get peat moss. The process is now on a commercial scale as Table I indicates.

Table I. Cuttings Rooted

YEAR	1939	1940	1941	1942	1943
January ...	265	477	361	351	409
February ...	252	339	351	314	348
March ...	237	307	591	353	383
April ...	294	539	296	688	554
May ...	714	587	325	636	1,008
June ...	702	670	299	1,109	280
July ...	715	777	323	643	968
August ...	842	787	443	797	465
September ...	1,072	943	438	775	421
October ...	750	378	315	414	360
November ...	319	472	359	785	375
December ...	642	320	553	542	408
Total ...	6,804	6,596	4,654	7,407	5,979

The figures should not be read as indicating the months that are best for rooting. In general the period of the "long rains", April-June, is best, but this is often masked by the numbers of cuttings which are ready for propagating. From 1940 to-date some twenty four acres have been planted in the field, in part for precise factorial experiments on cultural problems and in part for field trials of potential selections.

In general rooted cuttings bear in their second year, as year-old wood is used for cuttings, compared to seedlings which bear their first crop in the third year. That they are successful is indicated by the yields of a typical experiment which gave a mean yield of two cwts. of parchment coffee in the second year and nine cwts. in the third year, the average yield in Tanganyika Territory for all coffee being estimated at two and a half to three cwts. per acre.

So far the work of rooting cuttings on any scale in the Territory has been confined to this station and it is desirable, when normal conditions return, that professional nurserymen or "go ahead" planters should take up this work. It is justified if only on the grounds of uniformity in the merchantable type of coffee produced.

Equipment

The plant at this station comprises six batteries containing forty-six compartments each capable of dealing with about 200 cuttings. Cuttings take on average eighteen weeks to root. Thus in any one year about 18,000 can be set out.

Allowing for minor catastrophes such as "damping off", leaf-fall, cuttings which do not root within six months, and deaths from other causes, about 10,000 cuttings should root each year. That our results do not reach this number is so far due to lack of ample suitable material for cuttings. For "hardening off" after potting up there are twenty-four large single row frames built against the walls of three potting sheds. No special provision is made for further "hardening off" outside the frames except that artificial shade is provided. The potted cuttings stand on the ground and are subsequently planted in beds until required in the field.

The equipment is not described here in detail as it follows closely on that used at the Imperial College of Tropical Agriculture for cacao and has been described by Fernie (2).

Capital Expenditure—(pre-war prices)

The following quantities were employed in two 6-frame propagators erected by the station staff.

Material :	*Shs.*	*Cts.*
Timber	99	08
Wire Nails, 2"	1	36
Bolts, nuts and washers 8"×½"	1	49
Brass hinges, 4"	26	95
Barrels, Cement	96	36
Screws	2	09
Sheets, glass 18"×19" } Sheets, glass 18"×21" }	77	12
Sand, river	30	00
Stone (Shs. 1/50 a cubic metre)	40	00
½ Roll Wire netting (Concrete Work) 72"×½" mesh	40	00
Labour	65	00
Total	Shs. 479	45=£25 (approx.)

The Public Works Department erected the first two similar batteries for £30. Thus a fair amount to be charged to capital for the complete set of propagation is about £120. The lean-to frames cost about £50. The potting sheds, which are employed almost entirely on propagation work, cost £150 making a total of £320. This comprises all the capital expenditure.

Recurrent Expenditure

(*a*) *Materials :*	*Shs.*	*Cts.*
Peat Moss	110	00
Hessian Cloth for overhead shade	300	00
Decayed Coconut Fibre	60	00
Orthol K 5 gallons (7/50)	20	00
Hose ½" 120 feet	75	00
Watering Cans (Special rose)	16	00
Sand (Labour and Freight)	50	00
Wire netting 72"×2" (50 yd. roll for shade)	24	00
Canvas for side shade 2/75 per yd.	180	00
Glass for replacing breakages	20	00
Total	Shs. 855	00=£45 (approx.)

Compost is not included as it is difficult to apportion a fair cost. A reasonable estimate is probably in the neighbourhood of Shs. 3.50 per ton and mixed with soil and sand this quantity would supply very many baskets.

Thus, 10,000 rooted cuttings cost :—

	£	s.	d.
Writing off £320 Capital over ten years	32	0	0
Material	45	0	0
Total	£77	0	0

Cost per cutting is 15½ cents*=1¾d.

Labour

Coffee bushes are specially trained by bending over the stems to obtain readily material suitable for cuttings and the cost of this work would appear to be a fair charge against the true cost of rooting cuttings. The taking of the cuttings is done by a skilled labourer. Attention to the frames is skilled work and the men engaged are paid higher than ordinary labourers. Baskets are made by children on piece work from bananas grown on the station for mulching purposes. The upkeep of the bananas is small and a nominal sum only is debited to the baskets. The labour is thus :

	£	s.	d.
Propagator 1 at Shs. 50 per month	30	0	0
Skilled nurserymen 2 at Shs. 25 per month	30	0	0
Labourers 3 at Shs. 17.50 per month	31	4	0
Children baskets and weeding 3 at Shs. 12.00 per month	21	12	0
Total	£112	16	0

Cost per cutting in labour is 22½ cents*	....	=	2¾d.
The total cost per cutting is thus 38 cents*....	....	=	4½d.

It is seen that a rooted cutting of *Coffea arabica* costs 4½d. approximately in Tanganyika Territory, as compared with the 10d. for a cacao cutting in Trinidad.

Budding and grafting have only been done on a small scale in Tanganyika Territory and a comparison cannot therefore be made with this type of work.

References

(1) Cost of Cacao Propagation. E. E. Cheesman & G. E. L. Spencer. *Trop. Agriculture*, XVII, No. 9, 1940.

(2) The Rooting of Softwood Cuttings of *Coffea Arabica*—L.M. Fernie, *E. A. Agric. Jour.* March, 1940, page 323.

*These cents are East African Currency : (2,000 cents = £) and should not be confused with the Trinidad cents of which about 500=£1.

THE DETERMINATION OF POLARISATION % CANE FOR THE PURPOSE OF FIELD ALLOCATIONS OF SUGAR OR AS A BASIS OF CANE PAYMENT*

BY

L. S. BIRKETT, A.I.C.T.A., A.M. Inst. B.E.

(*Sugar Technologist, Blairmont Central Factory, British Guiana*)

For many years it has been the practice at Blairmont Estate to allocate to each field the sugar produced therefrom. The method involves the determination of the Pol. per cent. Cane and it is thought that a discussion of the subject would be of interest.

The Determination of Pol. per cent. Cane

The pol. content of the cane may be determined either directly or indirectly.

(*i*) *Direct Analysis.* Direct analysis of the cane is seldom performed as the sampling error is usually very great. A *representative* sub-sample of a batch of cane is usually so large as to be unsuitable for the purposes of routine laboratory tests. In this connection, investigations made in Queensland (1), (2) on the direct determination of fibre per cent. cane are of interest and should be consulted by those interested in the sampling of cane for direct analysis.

In South Africa, a cane sampling device has been tried (3) which appears to provide a more representative sample than is obtainable with the various hand sampling methods formerly used. It may be possible to develop this, or a similar device, to a point of efficiency where a sufficiently representative sample of cane for direct analysis may be obtained.

In experiments conducted by the writer, the determination of the pol. content of cane by analysis of the chipped pieces after passage of the cane through heavy duty factory knives gives a pol. content more closely approximating that obtained by the standard mill control method than is obtained by analysis of sticks of cane.

(*ii*) *Indirect Analysis.* (*a*) *Standard Mill Control Method.* The most accurate indirect method is that employed in the usual mill control whereby the pol. content of the cane is determined from the sum of the weights of pol. in the mixed juice and bagasse. While suitable for large quantities of cane, however, the method is impracticable for determining the pol. per cent. cane of relatively small batches as its accuracy depends upon the complete separation of the juices of any one batch of cane from that of another, and for the weights of imbibition water and mixed juice to be determined separately for each batch. Where batches for analysis are numerous, this involves frequent stoppages of the milling plant and interferes with the work of the factory. The method also requires considerable supervision to ensure that the separations are carefully made and that all samples are correctly taken. Further, since the number of samples of mixed juice and bagasse to be collected and analysed depends upon the frequency and number of changes of cane, analyses of these samples must be made at varying unpredictable time intervals which does not permit the establishment of a definite routine in the laboratory. Few factories can afford the loss of time which occurs in making the separations of the products of milling, and, when steam conditions are poor or a high milling rate must be maintained, the tendency is for the separations to be very imperfectly made. In such cases the method is not very accurate especially with very small batches of cane.

Due to these practical difficulties, the Java Ratio method affords a more satisfactory indirect method for use where the pol. content of relatively small batches of cane must be made. This method will now be considered.

(*b*) *The Java Ratio Method.* The Java Ratio method, or modifications of it, are widely used in the determination of the pol. per cent cane. In some quarters, however, this method is not considered to be sufficiently accurate for the purpose. The chief reason for this lack of confidence in its use appears to be due to the day to day variations in this ratio.

Spencer (4) states that the Java Ratio "has been found to be fairly constant for any given mill equipment irrespective of normal variations in the fibre content of the cane". It appears that this statement is often accepted as being strictly correct and consequently the daily variations in this ratio which do occur are viewed with suspicion. In actual fact, the fibre content of the cane is the chief factor responsible for variation in the Java ratio.

At Blairmont, the correlation between the value of the Java ratio and the fibre per cent. cane is always high. The relationship between these two variables for the year 1942 (calculated from daily figures) for instance, is as follows:—

Java Ratio = 102.234 — 1.7433 × Fibre per cent. Cane.

A similar relationship is found to exist if the data for several cane-growing countries be compared. Table I wherein is tabulated the mean crop data for a number of countries illustrates this.

The relationship between the Java Ratio and the fibre per cent. cane from the data in Table I is given by the following regression equation:—

Java Ratio = 101.946 — 1.6194 × Fibre per cent. Cane.

The correlation coefficient = —.863

The fact that the Java Ratio is influenced by the fibre per cent. cane has been recognised in Queensland for many years where the empirical

*With special reference to British Guiana.

Table I

Country	Year	Fibre % Cane	Java Ratio	Country	Year	Fibre % Cane	Java Ratio
Queensland (5) ..	1940	11.58	83.41	Puerto Rico (6) ..	1941	13.19	79. 7
	1939	11.56	83.45		1940	13.26	79.29
	1938	11.63	83.47		1939	13.22	79.27
	1937	11.17	83.83		1938	13.51	78.88
Formosa (7)	1938	11.68	83.62	Trinidad (8)	1941	14.60	78.03
	1937	12.18	83.44		1940	14.34	78.00
	1936	11.77	83.91		1939	14.35	77.65
Hawaii (9)	1938	13.38	83.35		1938	13.65	78.32
	1937	12.86	82.28	South Africa (10) ..	1941	15 66	77.74
	1936	12.63	82.29		1940	15.56	77.94
Mauritius (11) ..	1940	12.60	79.51		1939	14.80	78.70
	1939	13.00	79.04		1938	14.51	78.87

formula* in use for determining the pol. in cane is as follows:—

$$\text{Pol. in Cane} = P \times \frac{100 - (5 + F)}{100}$$

where P = Pol. in First Expressed Juice and F = Fibre in Cane.

The expression: $\frac{100-(5 + \text{Fibre in Cane})}{100}$ will be seen to give a factor similar to the Java ratio. In the Queensland formula, the relationship between this ratio and the fibre per cent. cane, is given by the following equation:—

$$\text{Ratio} = 95.00 - \text{Fibre per cent. Cane}$$

*Formula devised in 1888 by Dr. Kottman of the Colonial Sugar Refining Company of Sydney, Australia.

Since the Java ratio varies with the fibre per cent. cane, it may be argued that the normal variations in fibre per cent. cane are sufficiently great to render the method inaccurate. This argument may be valid where very wide variations in the fibre content of different batches of cane are to be found, but as far as the writer is aware, there are no published figures of tests comparing the value of the pol. per cent. cane by the Java ratio method with that obtained by the standard mill control method. Accordingly, tests were conducted at Blairmont Factory in 1940 and 1942 with this object.

The 1940 tests were made during a period of severe drought and would represent abnormal conditions, while those of 1942 represent normal conditions. The results of these tests are summarised in Table II.

It is thus seen that under normal climatic conditions (British Guiana), approximately 90 per cent. of the tests do not differ by more than ± .3 per cent. Pol. in Cane while under abnormal

Table II

Percentages of Tests differing by increments of ± .1 % Pol. in Cane

	1940	1942
Percentage differing 0 to ± .1 % Pol. in Cane	36.3	39.3
,, ,, ± .1 to ± .2 % ,, ,, ,, ...	23.0	32.2
,, ,, ± .2 to ± .3 % ,, ,, ,, ...	21.2	17.9
,, ,, ± .3 to ± .4 % ,, ,, ,, ...	9.0	7.1
,, ,, ± .4 to ± .5 % ,, ,, ,, ...	6.2	3.5
,, ,, ± .5 to ± .6 % ,, ,, ,, ...	3.7	nil
,, ,, ± .6 to ± .7 % ,, ,, ,, ...	.6	nil
Mean Pol. % Cane by Standard Mill Control Method	12.25	11.83
,, ,, ,, ,, ,, Java Ratio Method	12.21	11.84
Standard Deviation	± .25	± .21

conditions the percentage differing by not more than this amount is not below 80 per cent. However, it will be seen that in a number of individual determinations, differences may occur which exceed desirable limits. On the other hand, it should be noted that in the case of field allocations of sugar, tests are made of several batches of cane from each field. Similarly, were the method to be used as the basis for payment of cane on its pol. content, it would be unlikely that any single vendor of cane invariably record either a plus or a minus difference, or that all tests would shew excessive differences. Over a number of parcels of cane, the mean Pol. per cent. Cane as determined by the Java ratio method is likely to differ very little from the value obtained by the standard mill control method.

It may be concluded therefore, that under existing conditions in British Guiana, the Java ratio method of determining the Pol. per cent. Cane will be found satisfactory for purposes of field allocations or as a basis for payment of cane on its pol. content. Similarly, except where wide differences in the fibre per cent. cane of individual batches of cane occur, the method will be suitable.

Where wide variations in the fibre content of individual batches of cane occur, a closer agreement between the two methods of determining Pol. per cent. Cane may be obtained by analysing the cane for fibre per cent. and using the appropriate Java ratio from the regression equation giving the relationship between the Java ratio and the fibre per cent. cane for that particular factory. This would greatly increase the amount of laboratory work. Provided the calculations are confined to daily determinations of Pol. per cent. cane, the variations in most cases do not appear to be sufficiently wide to condemn the use of the daily value of the Java ratio.

Apart from cases of widely differing fibre content of individual batches of cane for analysis, the following conditions may also lead to errors which may exceed desired limits :—

1. Excessively wet cane, in which case the first expressed juice is diluted somewhat.
2. Rotten canes, or canes badly attacked by stem borers.
3. Excessive trash in the case of individual parcels.

Finally, it should be noted that close agreement between the Java ratio method and the standard mill control method does not necessarily indicate accuracy in the determination of the Pol. per cent. Cane. Since the Java ratio is obtained from the standard mill control data, any inaccuracy will in general be in the same direction and of the same magnitude as that of the standard mill control method.

References

1. Kerr, H.W. and Cassidy, N.G. *Technical Communication*, 1937, No. 2, Bureau of Sugar Experiment Stations, Brisbane.
2. Kerr, H. W., *Technical Communication*, 1938, No. 11, Bureau of Sugar Experiment Stations, Brisbane.
3. Christianson, W. O. *Proc. 14th. Congress South African Sugar Techn. Assoc.*, 1940, pp.135-144.
4. Spencer, G. L. "A Handbook for Cane-Sugar Manufacturers and their Chemists", 7th. Edition, p. 356.
5. *Annual Reports of the Bureau of Sugar Experiment Stations*, Brisbane, Queensland.
6. *Reports of the Association of Sugar Producers of Puerto Rico.*
7. *Annual Statements of the Association of Sugar Technologists*, Formosa.
8. *Reports of Sugar Manufacturers' Association of Trinidad.*
9. *Hawaiian Sugar Planters' Association Experiment Station Reports.*
10. *Proceedings of the South African Sugar Technologists' Association*, Durban.
11. *Revue Agricole, Mauritius.*

MISCELLANEOUS NOTES

The Bearing Problem of the Mango and its Control

The mango is a pronounced irregular bearer. The problem, which is complicated also by climatic vagaries, is associated with nitrogen depletion following heavy flowering as the result of which growth is inhibited. In order to produce blossom annually it is essential (1) to make the tree produce proper growth and (2) to induce a check in growth at the proper time to encourage fruit bud formation. This can be done in various ways. Briefly these are: (i) selection of varieties showing annual bearing tendencies, e.g., Dasheri and Fazli; (ii) wide spacing 30 feet to 40 feet, with windbreaks on the side of the hot winds; (iii) adequate but not excessive nitrogen supply; (iv) regular ploughing of the orchard three times a year; (v) annual manuring in October, the amount to be based on the appearance of the trees. Trees failing to produce sufficient new shoots in summer should receive sulphate of ammonia (5 lb. for a 6-year-old and 10 lb. for a 15-year-old tree) in June before the rains; (vi) irrigation soon after fruit set; (vii) ringing the main branches of 3 inch. to 5 inch. thickness in August, the ring to be ½ inch wide and at once plastered with grafting wax or a cowdung soil mixture. Ringing is only done where rainfall is over 30 inches and there are no late rains. (*Ind. J. Hort.*, I: 48-71).

The Problems of Humus in the Tropics and its Practical Significance

P. Vageler in an article in *Tropenfl.* 45, pp. 3-12, 33-52 reviews the present position of humus investigations in temperate climates and describes the humus problem in the tropics. Application of brown coal as an indirect fertilizer to exhausted tropical soils in the drier climatic zones should be considered, since brown humic substances increase the absorption capacity of exhausted tropical and sub-tropical brown earths.

AN IMPROVED WATER LIFT

BY

L. D. CLEARE

(*Department of Agriculture, British Guiana*)

IN *Tropical Agriculture*, Vol. XVII, No. 10, October 1940, the writer described a simple water lift which could be made by small cultivators and suitable for use in the West Indies and British Guiana.

Since then these water lifts have been in use to a limited extent in British Guiana and with the experience thus gained certain changes and modifications have been made which it is considered have improved the contrivance considerably. These have now been embodied in an improved form of water lift which will be described here.

The general principle of the water lift has not been changed and it is still made to be operated by hand. The most important points in the present model are its easier construction by a person not adept in the use of tools, which is considered important in a country where a large number of the rural population who undertake carpentry have been described as "cutlass carpenters"—possessors of a minimum of tools and who use the cutlass or machete to a considerable extent in place of many of the more orthodox tools.

It was found in the first model that the canvas belt to which the paddles were attached wore rapidly (by the friction of its passing over the drums and along the surface of the wooden tube of the lift), with the result that the paddles tore away from it and replacement was frequently necessary. In the present model this canvas belt has been replaced by ropes which run through the paddles about midway of their height so that the ropes do not come in contact with the wooden drums nor the upper surface of the water tube and wear is thus reduced to a minimum. In order to keep the paddles in place knots are made in the ropes on each side of each paddle. The use of ropes also has an advantage in that the belt may be shortened or lengthened easily if this is necessary either through the rope stretching with use or contracting when it becomes wet.

In the first model also the drums over which the belt passed were set out on wooden arms at the top and bottom ends of the wooden water tube. This called for some care in construction in fixing the exact position of the wooden arms and their angle in relation to the tube, which if not accurately carried out prevented the proper working of the contrivance. In the present model this has been overcome by extending upwards the sides of the tube, and now to place the drums correctly it is only necessary to mark off points from two directions and there bore the holes through which the drum shaft passes.

The lower drum is set in place when the tube is being put together. The upper drum is arranged so that it can be put into place or removed independently; this makes for easier construction repairs as well as in cleaning. The detail drawings show the construction of these parts.

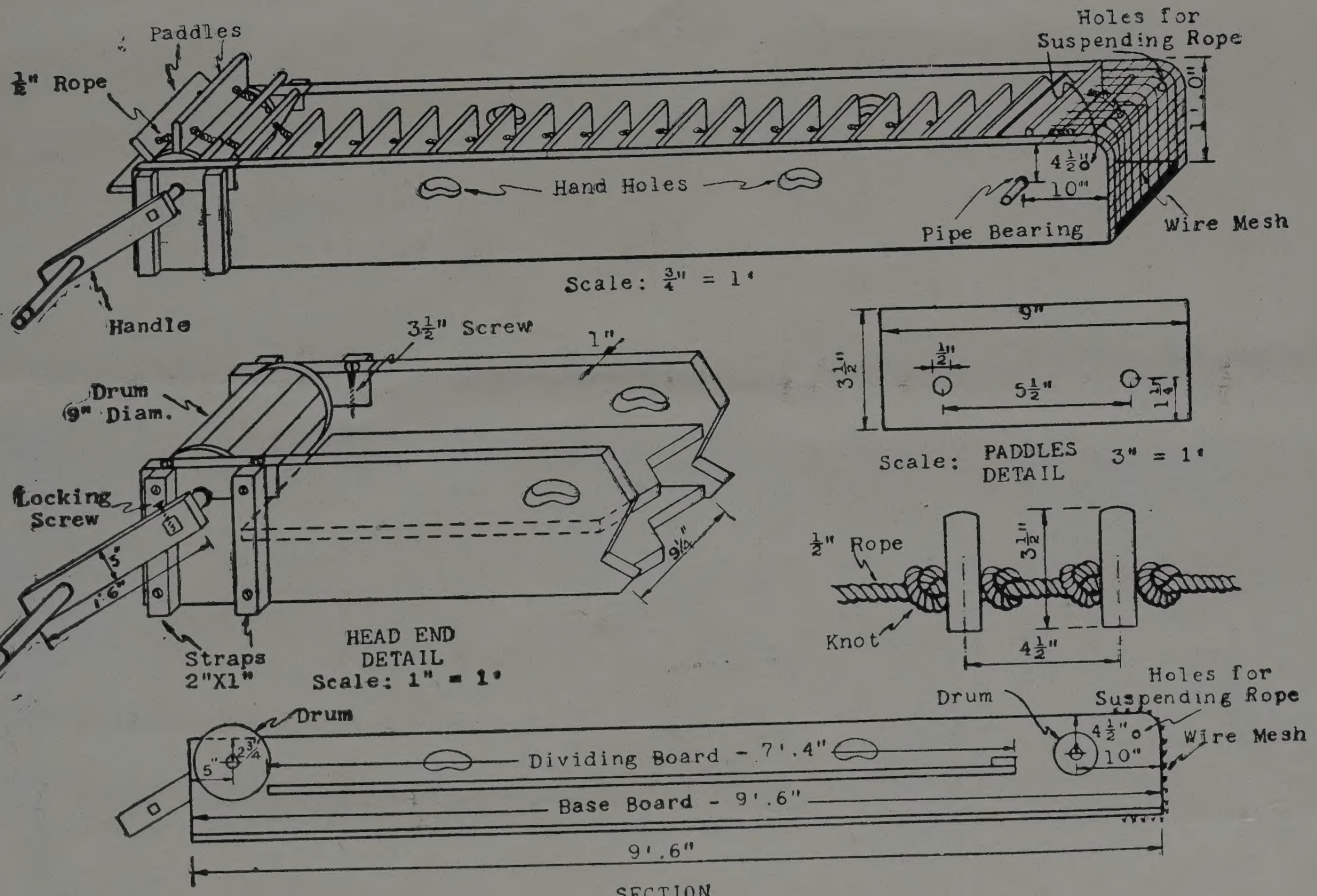
The extended side of the tube also serves to protect the paddles, and this also is considered an improvement; the four hand-holes at convenient places make for greater portability, and the screening of the lower end of the lift is carried out more easily.

Complete drawings are given of the present model in the accompanying figures.

If it is found necessary to construct a "horse" to support the upper end of the lift all that is required is two forked-sticks bearing a cross bar over which the lift may rest. What has been found to be of considerable advantage, however, is to regulate the depth at which the lower end of the lift is set in the water. This is done easiest by suspending the water lift by a rope. For this purpose the rope is passed through holes near the lower end and tied above, and the long free end of the rope is passed over another forked-stick which is placed upright in the canal. In this model two holes are bored in the hull for this purpose.

The following are the materials required for the construction of such a lift with a length of 9 feet 6 inches over all and a tube of 7 feet 4 inches long.

Wood		
Hull	....36 feet	....12″ × 1″ boards
Paddles	....12 ,,	.... do.
Drums	.... 4 ,,	.... do.
Straps	.... 1 foot	.... do.
Axles	.... 4 feet	....3″ × 1″ scantling
Handles (2)	4 ,,	....2″ × 2″ do.
Rope	....98 ,,	....(16½ lb.) ½″ diameter 1½″ circum.
Screws		
	....4 only	3½″ ¼ lb.
Galvanised	(1½ doz.	1½″ ½ lb.)
	2 doz.(4 only	1½″ ¼ lb.) ¾ lb.
Nails		
Sheet galvanised	3½ doz.	2″ (½ lb.)
	5 doz.	1″ (½ lb.)
Wire Mesh		
Galvanised	....¼″ mesh	....2′ x 12″ (⅜ yd.)
Staples		
Galvanised	....1½ dozen	....½″ (¼ lb.)
Piping		
For bearing	4 pieces brass	....1″ long 2″ inner diameter.


Paddles
½" Rope
Holes for Suspending Rope
1'-0"
4½"
10"
Hand Holes
Pipe Bearing
Wire Mesh
Scale: ¾" = 1'
Handle
3½" Screw
1"
Drum 9" Diam.
Locking Screw
5"
1'6"
9½"
Straps 2"X1"
HEAD END DETAIL
Scale: 1" = 1'
9"
3½"
½"
5½"
1½"
Scale: PADDLES DETAIL 3" = 1'
½" Rope
3½"
Knot
4½"
Drum
Holes for Suspending Rope
Wire Mesh
4½"
10"
5"
2¾"
Dividing Board - 7'.4"
Base Board - 9'.6"
9'.6"
SECTION
Scale: ¾" = 1'

STUBBLE-MULCHING AND SUBSURFACE TILLAGE*

Stubble-mulching and subsurface tillage are kindred operations which have lately attracted wide and, it seems, deserved attention on account of their efficacy in conserving soil liable to erosion. The purpose of stubble-mulching is to provide a "beard" or "blanket" of recently dead vegetation, rooted or not, as a mainly physical protection against erosion and run-off. The techniques are known by several names: "trashy fallow" is another term used in the United States, and particular aspects of it may be called "straw mulching" and "standing mulch." Mostert (1) in South Africa suggests that there is nothing new about the practice except the name and suggests the term "organo-mulch." It should be understood that these terms refer to arable crop land; the operation of mulching with straw, stems or stubble refers, in this connexion, to land otherwise bare of any crop, and the mulch is usually derived from residues of the previous mature crop (together with weeds allowed to grow more or less intentionally). Stubble-mulching thus differs from mulching in orchards, where a crop grown *in situ* for disking-in or to lie on the surface is usually a green crop or possibly an unripened cereal; also, in orchards the mulch may be of "imported" material strewn either over the bare soil or upon grass.

Leaving the stubble or trash on the surface does tend to enrich the soil in organic matter and also conserves the nutrients of the straw; but, while the exponents of stubble-mulching are alive to the importance of maintaining the organic-matter content of the soil, and welcome the conservation of plant material as a source of soil organic matter, the emphasis is primarily upon the physical nature of the impediment which the plant material lying upon the surface or half buried in the soil offers to the impact or erosive rain. The mulch does not merely act by preventing sheet flooding, but has the effect of breaking up the rain drops, thus reducing their size. The distance through which the drops then have to fall before striking the soil is, of course, very small, and their erosive or compacting effect is correspondingly small. These actions are of considerable importance. Laws (2) showed (with artificial rain) that with increasing drop size infiltration rate rapidly decreased, and the amount of soil eroded from a slope increased enormously. In another study with artificial rain on plots variously mulched Kidder *et al.* (3) pointed out that the practice of disposing commercially of crop residues is increasing the erosion hazard on sloping fields.

The system of stubble-mulching is broadly described as follows by H. H. Bennett (4) who says that it is "a revolutionary farm practice" and "the most promising conservation development of recent years."

"Stubble mulch" is a technical term employed by conservationists to define that process of protecting cultivated or bare land in such a way as to conserve soil and soil mositure and reduce evaporation through the use of a complete or partial surface covering composed of some form of crop stubble or residue. The mulching material may consist of (1) that portion of the stubble of a preceding crop, as wheat straw or corn stalks, left standing on the ground, or partially incorporated with the soil; (2) that portion of the stubble or litter left lying on the ground after such operations as threshing or combining; or (3) such material as hay, straw, or other plant residues hauled in and spread over the ground. The method involves special tillage operations that do not turn the soil over. These usually fall under two main types, namely, subsurface tillage and stirring without inversion . . .

"The stubble-mulching system is based on merely stirring the soil with plows that do not have mouldboards to turn all the vegetation or vegetative litter under. It leaves a considerable part of the vegetable material—crop residue or vegetative litter — on the land as a surface protection against erosion."

Subsurface tillage, or "farming through crop residues," thus consists essentially of using disc ploughs or else special cultivators which cut the soil in a plane parallel to the surface with a minimum of disturbance to the surface soil and to the weeds and crop residues on the surface. By the latter process the roots of weeds are cut. The disc plough half-buries the trash, and the true subsurface tillage implements leave practically all of the vegetable material on the surface. The machinery problems of subsurface tillage proper are still in the experimental stage (5).

Bennett (4) records that stubble-mulching has cut down erosion and run-off even more effectively than did basin listing, which some conservationists have looked upon as the best way of holding soil and rainfall on the land, particularly in low-rainfall areas. Protection of the surface by plants themselves or by organic litter which they furnish prevents sealing of the soil and is of the utmost importance in conserving moisture, said Beutner and Anderson (6) in a study of the effect of surface mulches on water conservation and forage production in some semi-desert grassland soils in Texas.

On arable land a widespread avoidance of inversion of the topsoil implies something of a revolution in agricultural teaching. The newer countries, wherein erosion and moisture conservation present problems practically unknown in those north-western European lands where the mould-board plough originated, may find that, generally speaking, the inversion plough is not the most suitable implement for their soils cf. (7). The use of the mouldboard plough in such countries may be, after all, little more than a traditional survival from the very different conditions of Western Europe.

* Reprinted from *Soils and Fertilizers*, VII, 2, 1944.

Some questions arising out of stubble-mulch farming are yet unsolved. Trash lying on the surface may harbour insect pests to a dangerous extent. The rôle of weeds and methods of combating them are matters still outstanding; but so, we suppose, they ever will be in any system of cultivation.

References

(1) J. F. T. Mostert, *Farm. Week. S. Africa*, 66, 1943 (563).

(2) J. D. Laws, *Agric. Engng.*, 21, 1941 (431-433).

(3) E. H. Kidder, R. S. Stauffer & C. A. Van Doren, *ibid.*, 24, 1943 (155-159).

(4) H. H. Bennett, *ibid.*, 23, 1942 (37-38, 42).

(5) F. L. Duley and J. C. Russel, *ibid.*, (3, 9-42) L. W. Chase, *ibid.*, (43-45, 50). H. A. Morehead, *ibid.*, (46, 64).

(6) E. L. Beutner and D. Anderson, *J. Amer. Soc. Agron.* 35, 1943 (393-400).

(7) R. A. Norton, E. V. Collins and G. M. Browning, *Agric. Engng.*, 25, 1944, (7-10).

CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Stubble Mulch in the Southern Piedmont

According to an article by B. H. Hendrickson, published in *Soil Conservation*, IX, 1943, stubble-mulch farming has found wide acceptance on the grain lands of the Pacific North-west and of the Great Plains. Crop residues used as stubble-mulch are effectively fighting wind damage on hundreds of thousands of acres in the "blow" States, and at the same time are conserving moisture, improving soil structure, and checking run-off. The practice is solidly entrenched in the West as a standard soil-management measure.

Some of the questions regarding tillage of stubble mulches are whether to turn them under, whether to turn them in and only partially cover them, or whether to loosen the soil by shallow ripping so as to leave them practically intact on the surface. In certain crop successions, no tillage at all seems best. Leaching of nitrogenous materials in surface residues due to weathering, and the nature of the decomposition complexes, with special reference to the evolution of nitrates from various residues are subjects on which more information is needed.

Wheat-straw mulch applied by hand in 1940 to one of two 11 per cent. slope run-off plots 70 feet long, which had been disk-harrowed and sown to Kobe lespedeza, showed astonishing ability to reduce erosion to a negligible quantity and to maintain the highest infiltration. The action of the close-growing summer annual, Kobe lespedeza, combined with the mulch, unquestionably enhanced its effectiveness.

The value of continued self-mulching has been shown by the subsequent performance of these two plots, since both of them have remained in pure stands for repeated seed production, leaving the full combine-harvest stubble mulches on the land. Soil and water losses have been very low. The plots have shown the best conservation record of any method under test, despite the severe erodibility of the site they occupy. In addition, seed production of 282 lb. per acre in 1942 on these two waste-land plots equalled, or exceeded the seed yields obtained on the best of the cropland fields.

Hand-applied straw mulching is hardly practical under farm conditions except for small critical areas. The results do show that practically complete control of soil and water loss was obtained even on steep slopes with the topsoil entirely washed away.

A heavy stubble-mulch such as that developed by well established kudzu with only reasonable quantities of hay removed provided almost perfect erosion protection and greatly reduce run-off losses. Kudzu residues ploughed under greatly stimulated maize yields on poor land unsuited to maize production by ordinary cropping methods.

The harvesting of all plant growth including roots is a serious soil-depleting practice. On the other hand, when only the seeds of egumes are combine-harvested, there is left on the field nearly all the plant materials, including leaves, stems and roots. These residues are rich in nutrient value and have both soil-protecting and fertilizing value. Lespedeza-stem mulch, as distinguished from the complete leaf and stem residues, has some apparent fertilizing value for the following summer crop. Non-legume mulch materials (*e.g.*, hegari) did not produce in the soil any appreciable effect tending to increase crop yields.

These results bear out the contention that practical conservation management of erodible croplands should favour cropping plans which provide for accumulations of legume residues to be left on the land.

Some of the implements and operations are illustrated.

Manurial Trials on Sugar Cane in Mauritius

According to the 13th *Annual Report of the Sugar Cane Research Station*, Mauritius (1942), manurial trials on the optimum quantity of nitrogen for sugar cane have been continued and one experiment was especially accurate. There was a big effect from the first increment, an undoubted value from the smallest application, and a doubtful utility of any quantity applied in excess. Experiments on methods and time of application were made, but the former are still in progress. The response to pen manure was very marked, and for each of N, K and pen manure it was found that the best results were obtained when the whole application was given at planting.